EXHIBIT E

Exponent®

Expert Report of Dr. Quinn Horn, Ph.D., P.E.

in the matter of

Marcellin, et al., Plaintiffs

vs.

HP, Inc., and Staples, Inc.

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Prepared for

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Contents

Executive Summary

Exponent, Inc. (Exponent) was retained by Coughlin Betke LLP to conduct an evaluation of the fire that occurred on January 24, 202 at 192 Bells Brook Road, Ceres, New York. The fire occurred at a residential home.

Materials Reviewed

Exponent reviewed the report from the Allegany County Fire Department from their investigation into the fire at 192 Bells Brook Road in Ceres, NY. Exponent also reviewed photographs taken by Greg Gorbett during the scene inspection on February 27, 2020 as well as photographs and CT scan data collected at the lab examination of the evidence on October 27, 2020. In addition, depositions and discovery materials produced by the parties in this matter were reviewed, including the following Plaintiff's expert reports:

- Report of Jason Karasinski, dated October 14, 2024
- Report of Andy Litzinger, dated October 14, 2024
- Report of Dr. Steve Martin, dated October 14, 2024

A full list of materials reviewed in this matter is provided in Appendix A.

Qualifications

I am currently employed by Exponent as a Principal Engineer and have been with the firm since July 2004. Exponent is an international science and engineering consulting firm with approximately 900 professional consultants. As a Principal Engineer at Exponent, I provide technical consulting services to clients in the areas of metallurgy and electrochemistry focused on battery technology. In the field of battery technology, my work addresses a broad range of issues including material selection and testing, cell design, cell manufacturing, performance degradation, accelerated life testing, due diligence technology evaluation, and failure analysis. I have worked extensively to develop characterization techniques for understanding electrode reactions and degradation mechanisms that result in performance, safety and reliability problems in a wide range of battery systems including lithium-ion.

Prior to joining Exponent, I held positions as a Principal Scientist at Physical Sciences Inc. (PSI), and as a Staff Technology Engineer at Energizer/Eveready Battery Company. At PSI, my work focused on the design, development, and testing of high-energy and high-power electrodes for lithium-ion batteries. At Energizer, I was responsible for the Microscopy and Materials Group, where I conducted failure analysis studies to solve problems related to battery failures and battery manufacturing issues.

I am a Research Affiliate at the Massachusetts Institute of Technology, where I collaborate with researchers in the Electrochemical Energy Laboratory on projects related to electrochemical storage and conversion.

I currently hold four patents in the field of battery technology. I am the first author of an appendix chapter in the 4th edition of the Handbook of Batteries on methodologies for failure analysis of batteries. I have also co-authored several publications and given numerous presentations on the topics related to battery performance, reliability, safety, and failure analysis.

I earned my BS and MS degrees in Metallurgical Engineering in 1993 and 1995, respectively, from Michigan Technological University and my Ph.D. in Metallurgical and Materials Engineering in 1998 from Michigan Technological University. I was a Department of Defense Research Fellow while working on my graduate studies from 1994 to 1997.

I am a Licensed Professional Engineer in the State of Maryland and an active member of the Electrochemical Society.

My curriculum vitae is attached as Appendix B of this report, and it includes a summary of my experience, along with a complete list of my patents, patent applications, book chapters, publications, and professional presentations. A list of my testifying experience from the last four years is also attached as Appendix C. Exponent charges a rate of $695 per hour for my time through the end of calendar year 2024. Neither my nor Exponent's compensation for my professional analysis and testimony is contingent upon the outcome of this lawsuit.

Executive Summary of Findings

Controlling Document and Content of this Report

This Executive Summary does not contain all of my technical evaluations, analyses, conclusions, and recommendations. Hence, the main body of this report is at all times the controlling document.

My Primary Opinions

Based on my education, background, training, experience, analysis, and review of the relevant materials, I offer the following opinions in this matter to a reasonable degree of scientific and engineering certainty. If additional information becomes available, I reserve the right to modify or amend these findings:

1. The battery pack of the alleged subject HP Pavilion DV6 notebook computer was inconsistent with the genuine, original battery pack that would have been sold with this HP model. As such, protections provided by the original pack may not have been present in the battery pack that was installed in the notebook at the time of the fire, which could have led to degradation of the performance and safety characteristics of the cells.

2. While the Subject battery pack was of unknown origin and lacked protection features that could prevent abuse of the included battery cells, the evidence is consistent with the subject battery pack experiencing thermal runaway due to external heat attack from the fire.

Responses to Dr. Martin and Mr. Karasinski

Dr. Steve Martin and Mr. Jason Karasinski submitted expert reports for other parties in this matter and provide opinions that are relevant to the root cause of the incident, battery cells found at the scene, and exemplar notebook computers procured for testing. I provide comments on their opinions presented therein in Sections 5 and 6, respectively, of this report, and contentions with their overall conclusions are discussed.

1 Background

1.1 Battery Overview

Batteries are devices that can store and release electrochemical energy. They operate by storing energy through chemical bonds in the batteries' electrodes, and then generate electrical energy through a controlled chemical reaction process, which produces current through an external circuit. Batteries can be designed to either be single use ("primary") or rechargeable ("secondary") and can contain a wide range of different internal chemistries. Rechargeable batteries contain reversable chemical reactions and are capable of repeatedly being charged and discharged depending on the presence and direction of the external electrical load. During charge, external energy is added into the battery and stored through chemical bonds in the battery's electrodes, and then during discharge the chemical reactions formed during charging are reversed, and electrical energy is released to an external circuit.

1.2 Lithium-Ion Battery Cell Basics

Lithium-ion battery cells are a specific type of rechargeable battery that rely upon the transport of lithium ions from one electrode to another to store and release energy. The lithium ions will intercalate or bond with the electrode materials upon charge or discharge, thereby releasing or accepting electrons from the external circuit. Lithium-ion battery cells are made of 5 major active components: a positive electrode, negative electrode, separator, electrolyte, and a mechanical housing to contain the internal components and provide electrical contact to the end application. The positive electrode is comprised of an electrochemically active material, typically a lithium metal oxide, coated onto an aluminum foil current collector, while the negative electrode is typically a graphite-based material coated onto copper foil. In both cases the metal foils act as a current collector, facilitating the efficient movement of electrons throughout the cell. The separator is typically a porous insulating polymer that acts to keep the two electrodes electrically isolated from one another while enabling ion transfer between the electrodes. Without adequate electrical and physical separation of the electrodes, the lithium ions could immediately, and uncontrollably, transfer between the electrodes, rapidly releasing any stored energy in the cell. This phenomenon is known as an internal short circuit.

As shown in Figure 1, the main layers of the battery cell internals (positive and negative electrodes, current collectors, and separator) are stacked in a repetitive sequence. This grouping of layers can either be wound together, as shown below, or stacked to fill the cell container. Increasing the active material in the cell increases the amount of possible stored energy.

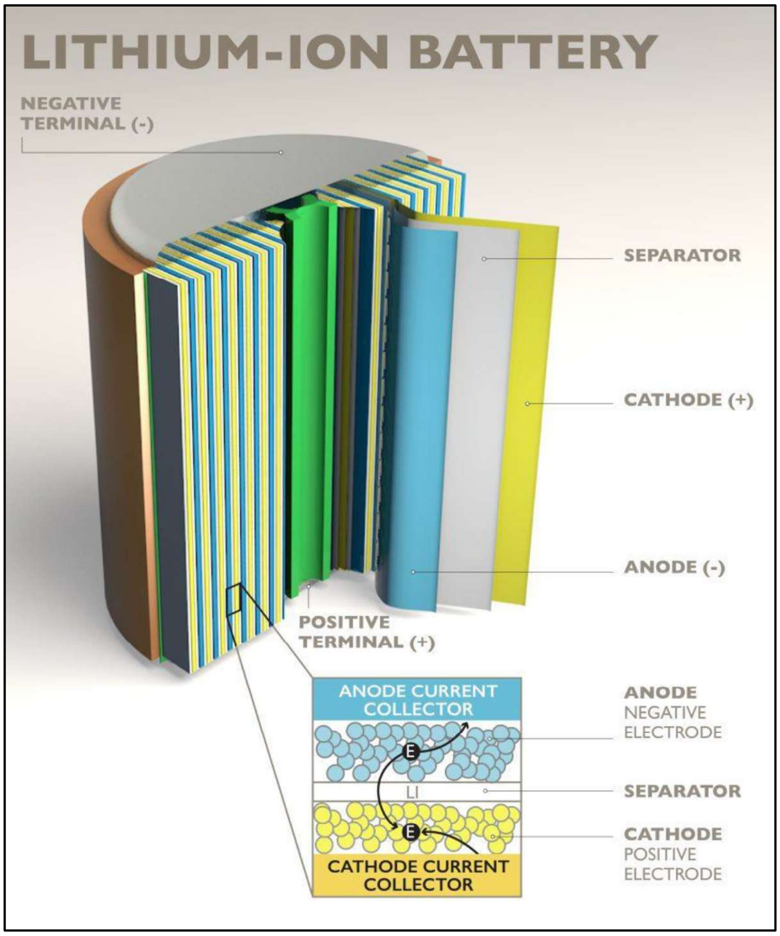

Figure 1. Schematic of the interior of a cylindrical cell. Image courtesy of https://www.xerotech.com/news/pros-cons-of-battery-cell-types/

Lithium ion battery technology has become increasingly advanced over the last thirty years, maturing into an industry that supports a wide array of today's electronic applications, ranging from consumer electronic devices to large scale electric vehicles. Lithium-ion battery cells come in many shapes and sizes, but generally have an exterior that consists of one of three formats: cylindrical, pouch, or prismatic. In all cases, the electrode stack is placed inside a container, which forms a hermetic seal around the battery and provides a mechanical enclosure to protect the electrode stack. Before sealing, liquid electrolyte is added to the container, which fills the pores in the separator and spaces within the electrode active materials. The electrolyte, which typically contains a lithium salt (e.g., $LiPF_6$) dissolved in a solvent, enables the transfer of lithium ions between the two electrodes through the porous separator during charging and discharging.

1.3 Cylindrical Cell Construction and Common Safety Features

The majority of the lithium-ion battery cells recovered as evidence in this case were cylindrical format cells. Cylindrical cells are a common lithium-ion battery format and have a distinct construction relative to other cell types. These cells typically use a nomenclature where the cell name refers to its dimensions and form factor. For example, one of the most common types of lithium-ion cylindrical cells is the "18650", where the cell has a diameter of 18 mm ("18"), a

length of 65 mm ("65"), and a cylindrical form factor ("0"). Figure 2 shows an exploded view of many common construction features present in cylindrical cells, including the electrode stack ("jelly roll"), can housing, electrical isolation components, and select safety features. While the cell's design and materials used will vary between cell models, many construction features are common. For example, cylindrical cells typically utilize a metal can housing, a nickel negative tab, an aluminum positive tab, and polymer isolation spacers. The positive tab is welded to the positive current collector foil as well as the positive top cap assembly, and the negative tab is welded to the copper foil as well as the cell can, which acts as the negative contact to the external load. These tabs act as "highways" for electrons that are generated/consumed during the electrochemical reactions, enabling faster transport of current and more efficient cell operation. The exterior metal housing (typically a nickel coated steel for 18650 cells) provides mechanical stability and protection to the electrode windings, while insulating spacers are placed at each end of the electrodes to prevent short-circuiting of the cell from accidental contact between the electrodes and the can housing.

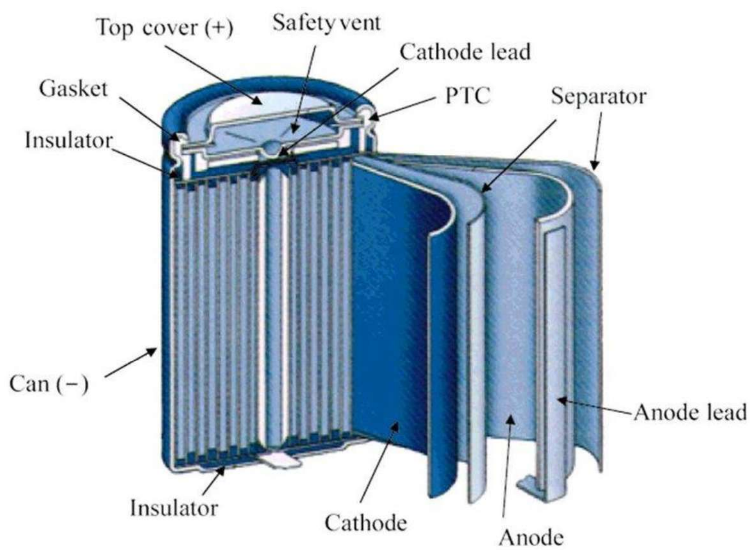

Figure 2. Schematic of common construction features in a cylindrical lithium-ion battery. Image courtesy of O. Bankole *et al.*[1] (https://www.researchgate.net/figure/The-structure-of-a-cylindrical-lithium-ion-battery_fig2_272662523)

In general, cylindrical lithium-ion battery cells are intended to be incorporated into battery packs, and the individual cells themselves are not intended to be handled by end consumers. Once incorporated into a pack with appropriate protective circuitry and mechanical protection, the "cells" become a "battery".

Safety features commonly included in cylindrical cell designs are a current interrupt device (CID), a burst disk with a pre-scored vent, a positive temperature coefficient device (PTC), a fusible positive tab, and a shutdown separator. These features are typically designed to activate in abuse

[1] O. Bankole, C. Gong, and L. Lei, "Battery Recycling Technologies: Recycling Waste Lithium Ion Batteries with the Impact on the Environment In-View", *Journal of Environment and Ecology,* **4,** 1 (2013).

scenarios and attempt to disconnect or deactivate the cell to mitigate thermal failure of the cell. Most of these safety features can permanently isolate the cell from any external current loads.

1.3.1 Current Interrupt Device

The current interrupt device (CID) is a protection feature designed to disconnect the cell's internal positive tab from the cell's exterior positive terminal when the pressure within the cell becomes too high, which typically happens from excessive heating or gas generation from side reactions within the cell. The mechanism is mechanically activated by the gaseous pressure within the cell and severs the electrical connection between the internal positive tab and external positive terminal. This action electrically isolates the electrode windings from the cell exterior, which stops the flow of electricity in or out of the cell, preventing further charging and discharging of the cell by an external circuit. The CID is typically designed to activate at a specific pressure and is intended to prevent failure in overcharge or other electrical abuse scenarios in which gas is slowly generated inside the cell.

1.3.2 Burst Disk

The burst disk, and the associated gas release vent, is another pressure activated safety mechanism in the cell's top cap assembly. After the CID disk has disconnected from the burst disk (thus preventing current flow external to the cell), if reactions within the cell continue such that gas pressure continues to increase, the burst disk is designed to rupture to relieve the pressure through the designed vent holes in a controlled manner. This venting process is designed to occur without the rupture or explosion of the cell can.

To allow the burst disk to operate at a specific pressure below the rupture strength of the cell can, a score is typically stamped or etched into the burst disk to intentionally create a weak spot, at which the burst disk opens. The rate at which the burst disk can release pressure is restricted by the size of the disk, and the openings created during activation. For cases where there is a pressure rise in the cell beyond the release rate that the burst disk can accommodate, pressure will continue to increase, and the cell is then typically designed to "uncrimp" and release the top cap assembly to prevent an uncontrolled rupture of the cell can.

1.3.3 Positive Temperature Coefficient Device

The positive temperature coefficient (PTC) device refers to a layer of material, which may be present in a cell's top cap assembly and is intended to restrict current flow in or out of the battery during excessive temperatures or current scenarios. PTCs are designed to be electrically conductive during nominal conditions (ambient temperature and low to moderate current) but turn to an electrical insulator at elevated temperatures or high currents. As the resistance of the PTC increases with increasing temperature, the amount of current capable of being passed is reduced, ultimately to negligible levels. As a consequence of how PTC devices operate, they are generally only suitable for high-energy, and not high-power applications, as the current draw during high-power use could activate the PTC device during nominal operation.

1.3.4 Shutdown Separator

As introduced above, the porous polymeric separator used to separate the positive and negative electrodes allows ions and liquid electrolyte to flow freely between the electrodes, while preventing electrical conduction. The separator also serves to "shut down" an uncontrolled reaction when the cell temperature gets too high, as the separator transitions from a porous to non-porous material(s) and restricts lithium-ion movement between electrodes. While different "shutdown separator" technologies exist (including different separator chemistries, multiple layered systems, and the addition of surface coatings), the basic operating mechanism remains the same. As the cell reaches sufficiently high temperatures, either locally or globally, the shutdown separator begins to transition to a non-porous system and prevents ion movement within the cell.

1.4 Cell Identification

The combination of the basic physical construction features of a cell in conjunction with the design of the safety features described above can create a "fingerprint" for a cell and can help identify the manufacturer and cell model or determine if cells were designed by the same manufacturer. Different cell manufacturers have different tooling and use different vendors for their components (which, in the case of cylindrical cells include the cell can, tabs, and the positive cap assembly). Such tooling and component differences manifest in observable features, including the physical dimensions of the tabs, the number and design of the vent holes, the geometry of the CID and burst disk, as well as embossment patterns used during the various welding procedures of the cap and tabs.

In failure analysis scenarios where cells are being examined after thermal runaway, many of the aluminum based internal cell components such as the positive tab, positive current collector, CID, and burst disk will have melted as a result of the thermal event. During thermal runaway, internal cell temperatures can exceed 800 °C[2], which is higher than the melting point of aluminum (~660 °C). However, components made of nickel and steel, which melt at 1,455 °C and 1370 °C, respectively, will typically exhibit less severe damage. Thus, the negative tab and can designs are often used to identify and contrast cell models during fire scene investigations.

1.5 Cell Failure Mechanisms

Lithium-ion batteries are reliable for storing energy and are safe when used as intended by the cell and pack manufacturers; however, there are multiple mechanisms that can result in battery failure and thermal runaway. Thermal runaway refers to the rapid self-heating of a battery cell derived from the exothermic chemical reactions of a highly oxidizing positive electrode and highly reducing negative electrode. In a thermal runaway reaction, a cell rapidly releases its stored energy and often results in the ejection of hot gases and materials, sparks, and flames. The more energy a battery has stored, the more energetic a thermal runaway reaction can be.

There are many ways to exceed the thermal stability limits of a lithium-ion battery and cause an energetic failure. Battery failures may be induced by external forces such as exposure to thermal,

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[2] L. Yuan *et al.*, "Experimental study on thermal runaway and vented gases of lithium-ion cells", *Process Safety and Environmental Protection*, **144**, (2020), pp. 186-192.

mechanical (e.g., crush, impact, shock, etc.), or electrical abuse (e.g., overcharge, overcurrent, and overdischarge and subsequent recharge). Additionally, batteries may also fail from internal cell faults resulting from poor cell design or manufacturing issues, or from undesired side reactions within the battery, which in extreme scenarios can lead to the development of an internal short-circuit; however, even if a battery cell has an internal fault, failure of the cell is highly unlikely without some sort of external stress, such as charging or external abuse.

Despite the failure mechanisms that exist, lithium-ion batteries are a safe and mature technology when used as intended. The cells are typically equipped with multiple internal protection features, as noted above, and are intended to be integrated into battery packs, which provide additional protections against abuse and misuse. While many of the cell's internal safety mechanisms are designed to reduce the likelihood of failure from an external abuse or an internal fault, none are capable of completely preventing all failures.

1.6 Battery Pack Protection and Safety Features

As mentioned above, cylindrical lithium-ion cells are intended to be incorporated into battery packs that provide appropriate mechanical housing and protective circuitry to ensure that the cells are used within specification and in the proper application. 18650 battery cells in particular are a ubiquitous form-factor in the battery industry, which helps ease the geometric design considerations for battery pack assemblers, but also makes it vital for such products to have properly designed electronics that protect the energy-dense cell(s). While the extent and sophistication of the included protection features may vary, the battery pack typically contains an enclosure to provide some mechanical protection to the cell(s), and a battery management system (BMS) for electrical protection. The BMS is comprised of circuitry that is designed to mitigate electrical abuse of the battery during operation. Even for battery packs with proper mechanical and electrical protection features, failures can still occur, especially during abuse scenarios outside the control of the BMS (e.g., external heating, severe mechanical damage, moisture ingress, etc.).

2 Case Information, Inspections, and Evidence

According to the complaint filed on June 2, 2021, a fire occurred on January 24, 2020, at a residential building at 192 Bells Brook Road in Ceres, New York. The Allegany county fire service performed a walkthrough after the fire was contained, on January 24, and there was subsequently an on-site inspection on February 27, 2020. The following attendees were present at the scene inspection:

- Bryan Davis, NEFCO (Representing Farmers Insurance)
- Scott Phillips, Forensic & Failure Analysis (Representing Farmers Insurance)
- Joseph Tomizzi, Peter Vallas Associates (Representing Staples)
- Paul Simonian, Peter Vallas Associates (Representing Staples)
- Matthew Belanger, Faraci Lange Attorneys (Representing the Estate of Hollowell)
- Andy Litzinger, Fire Research Technology (Representing the Estate of Hollowell)
- Jason Karasinski, Fire Research Technology (Representing the Estate of Hollowell)
- Gregory Gorbett, Fire Dynamics Analysis (Representing HP)
- Jeff Luckey, Allegany County Emergency Services & Fire (Representing Allegany County Fire Office)

At this scene inspection, visual inspection of the home was conducted, and photographs were taken. A 3D Matterport scan was created from the images taken at the scene.

Following the on-site inspection and evidence collection, a lab examination occurred on October 27, 2020. The following attendees were present at the lab exam:

- Scott Phillips, Forensic & Failure Analysis (Representing Farmers Insurance)
- Paul Simonian, Peter Vallas Associates (Representing Staples)
- Joseph Tomizzi, Peter Vallas Associates (Representing Staples)
- Christopher Harvey, Pillinger Miller Tarallo (Representing Staples)
- Nicholas Vincenzo, Center Engineering (Representing Staples)
- Matthew Belanger, Faraci Lange Attorneys (Representing the Estate of Hollowell)
- Andy Litzinger, Fire Research Technology (Representing the Estate of Hollowell)
- Jason Karasinski, Fire Research Technology (Representing the Estate of Hollowell)
- Donald Galler, Electrical Engineering Solutions (Representing HP)
- Jeff Luckey, Allegany County Emergency Services & Fire (Representing Allegany County Fire Office)

At the lab inspection the following analysis was completed:

- Visual inspection of all evidence items
- 2D X-ray imaging of select items

2.1 Scene Inspection

At the scene on February 27, 2020, visual inspection of all rooms in the home was completed. I have reviewed photographs from the fire scene investigators as well as the reports from the Fire Research, and Technology experts on behalf of the Estate of Hollowell. At the scene, the Subject Notebook was located in the office. Figure 3 shows an annotated version of a schematic of the office layout.

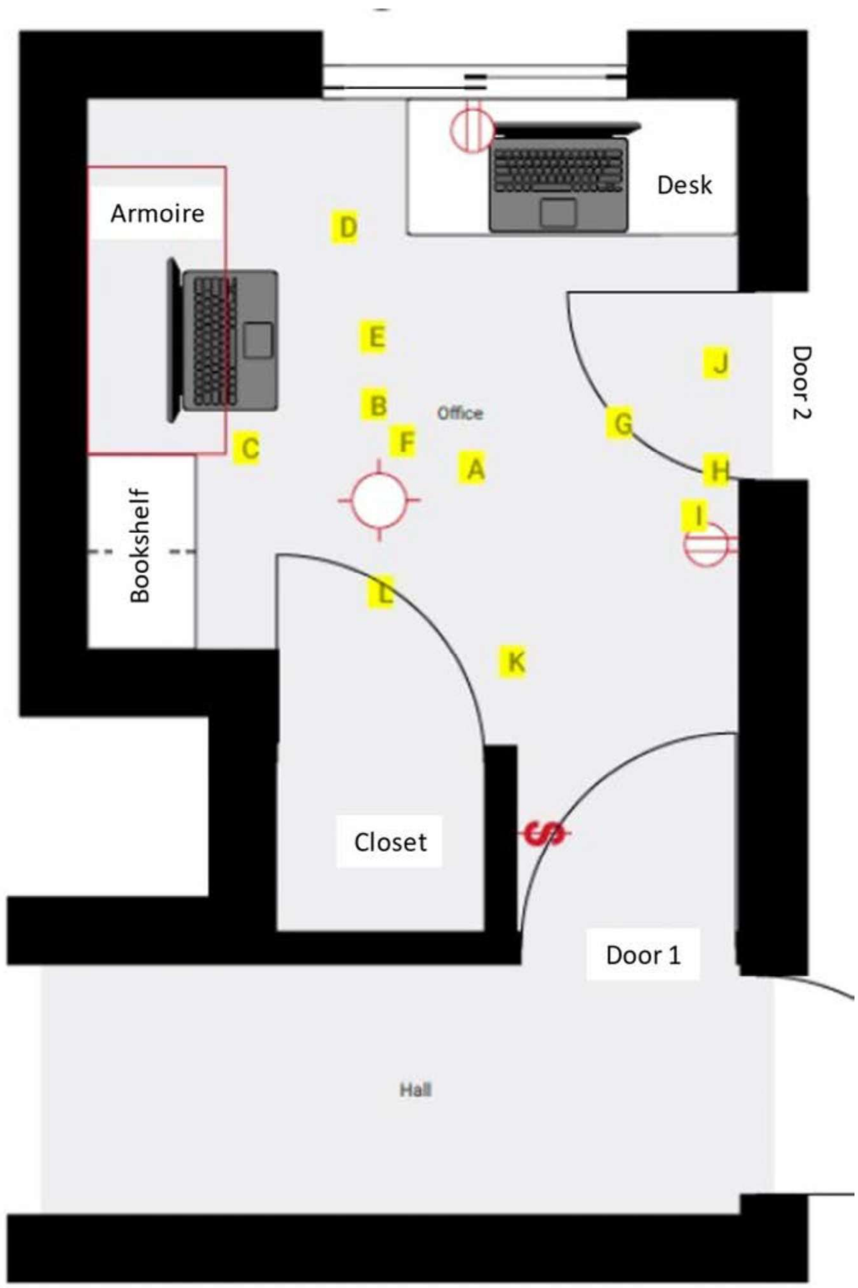


Figure 3. Annotated schematic layout of the office. The base schematic was taken from the report of Mr. Karasinski, and the text annotations were added.

In the office, the remains of a desk, desk chair, armoire, a bookshelf, and closet were observed. At the time of the inspection, Door 1 was opened, and Door 2, which led to a bathroom, was closed. The wood closet door, with an attached ironing board, was swung open, and the doors to the armoire were also angled open. An HP Pavilion DV6 notebook (henceforth referred to as the Subject Notebook) was observed on a shelf in the armoire, and the notebook was connected to a charger at the time of the inspection. The screen of the notebook was open. The polymeric casing around the screen, the keyboard, and the remaining notebook housing materials had melted, and there was a rupture in the notebook housing in the region of the battery pack. Two battery cell cans were observed remaining inside the battery compartment of the notebook. These cell cans appeared to have decrimped and ruptured, and windings had been ejected. Images of the armoire and Subject Notebook are shown in Figure 4.

Figure 4. Scene photographs of a) the armoire (Greg Gorbett image DSC 1600) and b) HP Pavilion DV6 notebook computer (Greg Gorbett image 1628).

An additional HP notebook was observed on the desk, as shown in Figure 5. The notebook was closed, and it did not appear to be plugged in at the time of the scene inspection. The desk surfaces, chair, and carpet/flooring surrounding this region appeared to have sustained more limited thermal damage as compared to other regions of the room, including the closet.

During the scene inspection, the desk was moved away from the wall in order to investigate the regions of the flooring underneath and behind the desk surface. During this process, sections of curtains and other debris were observed resting on the floor behind the desk. When this debris was cleared, two battery cells were found in the corner of the room. Both cell cans had decrimped and ejected their internal windings, and some of these windings were found nearby the cells. There was no thermal damage or ignition of the carpet, flooring, or other combustibles in the region where these cells were observed. Images of this region of the office are shown in Figure 6.

Figure 5. Photograph of the desk in the corner of the office (Greg Gorbett photo DSC 1562)

Figure 6. Photographs of the region of the office behind the desk. Curtains other debris (image a, Greg Gorbett photo DSC 1824) and two battery cells (image b, Greg Gorbett photo DSC 1833) were observed.

Various pieces of additional evidence, labeled A – L in Figure 1, were found on the floor scattered throughout the center of the room. An overview of these items is shown in Figure 7.

Figure 7. Photograph of the floor of the office (Greg Gorbett photo DSC 1732), with evidence labels for recovered items from the scene.

Partial ejected battery cell windings were observed at points H, I, J, and K, and cell can components/remnants were observed at points A, C, and E. The remains of two battery cells were found at point F. A close-up image of these cells is shown in Figure 8. The remains of a purple cell wrapper were found adhered to each of the cell cans, and it appeared that these cells were externally connected in parallel. An additional battery cell positive cap was found loosely adhered to one of the cell cans. This cap had a five-vent hole design.

The closet adjacent to Door 1 to the office was also investigated, and in image of this region is shown in Figure 9. Elevated thermal damage was observed on this side of the room as compared to the side with the desk, chair, and window.

Figure 8. Photograph of the two battery cells with purple wrapper remnants found at point F on the floor of the office (Greg Gorbett photo DSC 1721).

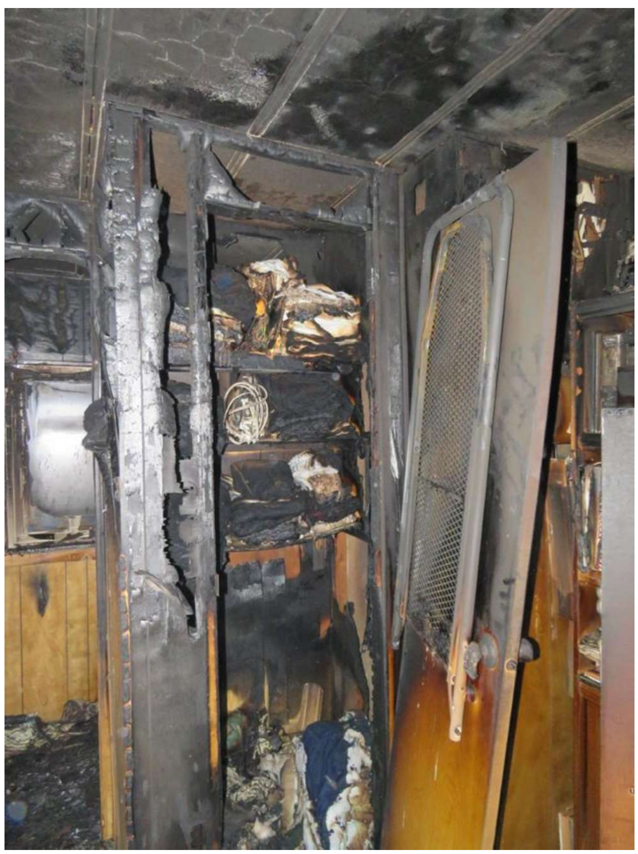
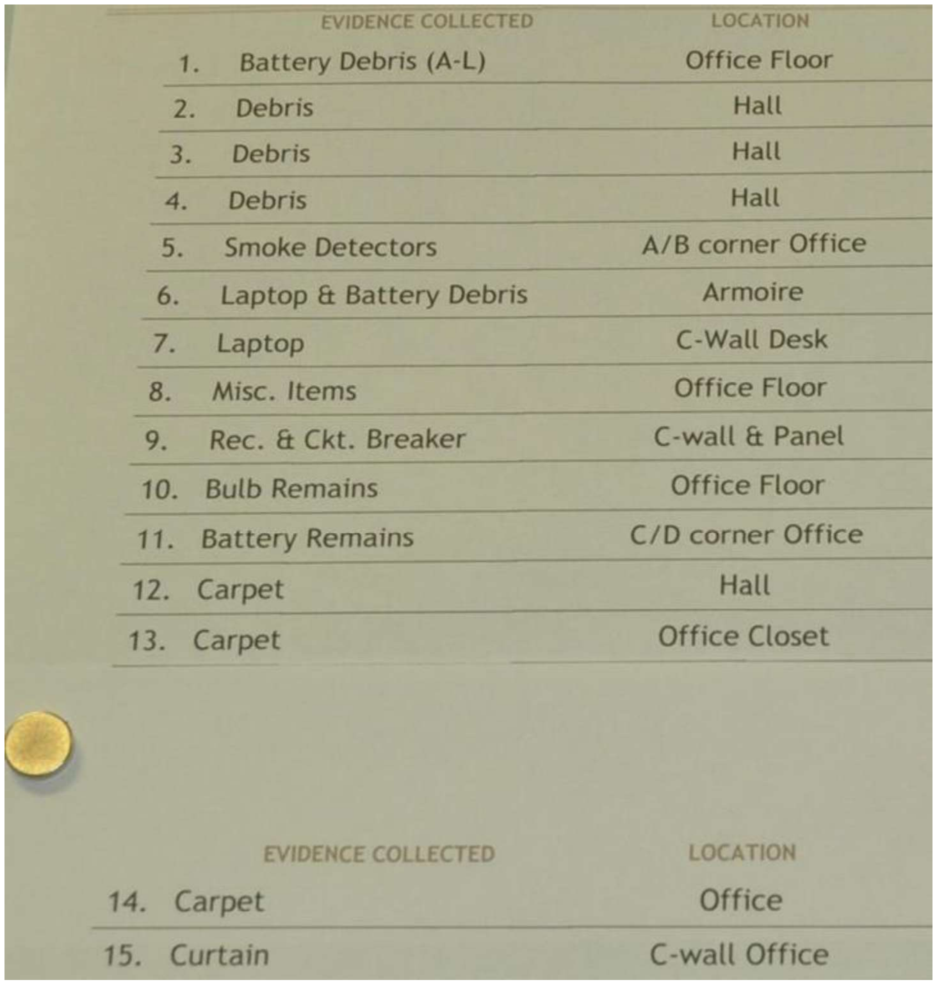


Figure 9. Photograph of the closet (Greg Gorbett IMG-7760-001)

2.2 Laboratory Exam

A laboratory exam of the evidence collected from the fire scene was conducted at Fire Research & Technology at 7317 NY-14, Sodus Point, NY 14555 on October 27, 2020. Figure 10 details the evidence that was collected from the scene and provided for inspection at this exam. I did not attend this evidence exam, but I have reviewed photographs taken by Mr. Don Galler as well as CT and 2D X-ray images collected during the exam.



	EVIDENCE COLLECTED	LOCATION
1.	Battery Debris (A-L)	Office Floor
2.	Debris	Hall
3.	Debris	Hall
4.	Debris	Hall
5.	Smoke Detectors	A/B corner Office
6.	Laptop & Battery Debris	Armoire
7.	Laptop	C-Wall Desk
8.	Misc. Items	Office Floor
9.	Rec. & Ckt. Breaker	C-wall & Panel
10.	Bulb Remains	Office Floor
11.	Battery Remains	C/D corner Office
12.	Carpet	Hall
13.	Carpet	Office Closet
	EVIDENCE COLLECTED	LOCATION
14.	Carpet	Office
15.	Curtain	C-wall Office

Figure 10. Evidence presented for inspection at the lab exam on October 27, 2020 (Don Galler photo 001)

Six 18650 battery cell cans, with external tabbing consistent with a 3 series 2 parallel (3s2p) configured pack that was likely installed in the Subject Notebook, were recovered from the scene, along with the remains of the notebook. These cells were found as part of Item 1 in Figure 10 (sub-item F), Item 7 (the notebook), and Item 11 (battery remains in the corner of the office). I assigned each of these cells numbers as follows:

- Cells 1 and 2: Item 1 sub-item F (found on the floor in the center of the room)
- Cells 3 and 4: Item 7 (still in the notebook)
- Cells 5 and 6: Item 11 (corner of the office behind the desk)

During the lab examination, Cells 1 and 2 were visually inspected and, it appears, put into a 2D X-ray imaging machine. Photographs of the cells are shown in Figure 11.

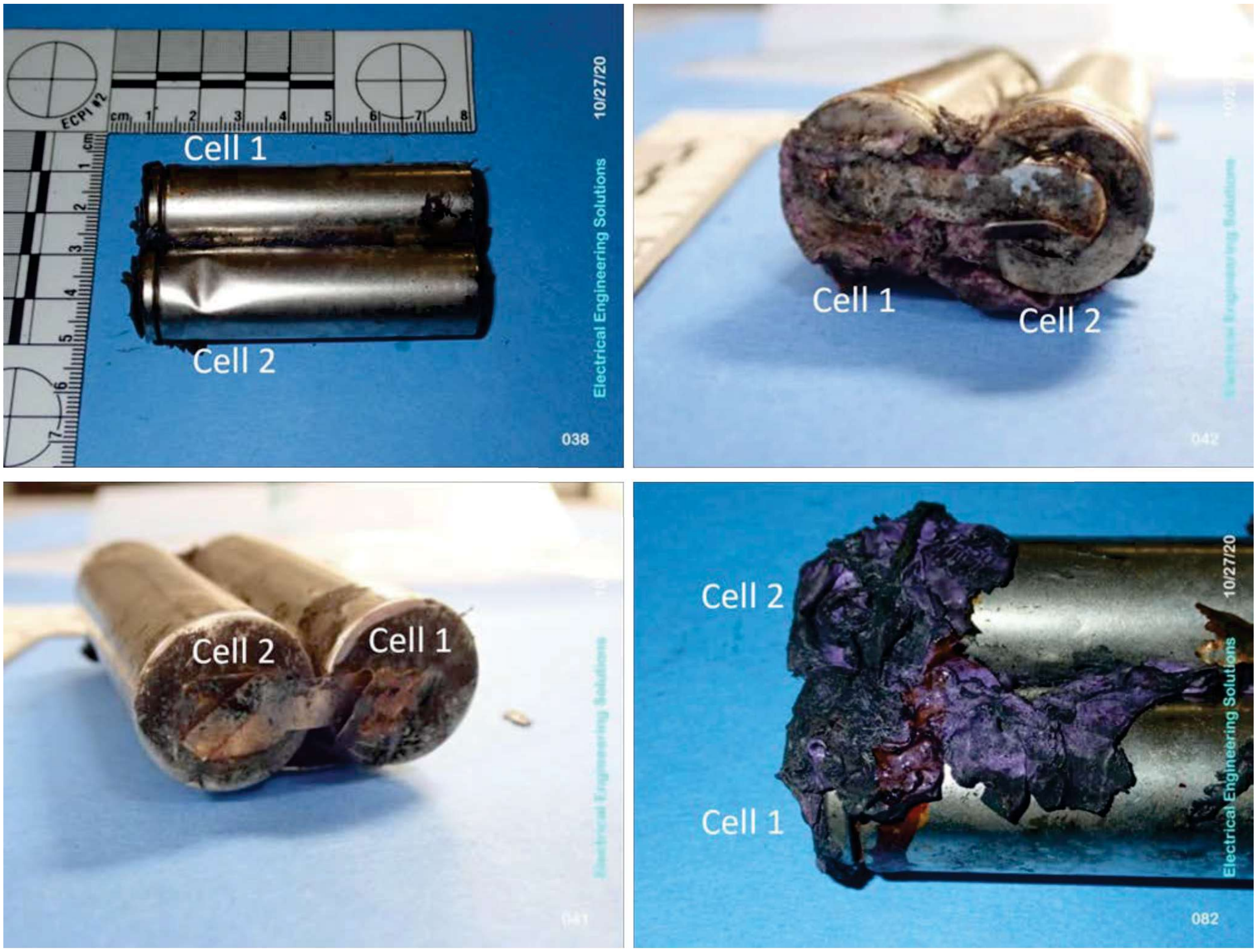


Figure 11. Annotated photographs of Cells 1 and 2 (Don Galler photos 38, 41, 42, and 82)

Cells 1 and 2 were 18650 cells that appeared to have a purple wrapper. They were externally tabbed in parallel and appeared to comprise one of the cell blocks in the Subject Notebook pack. A dent consistent with mechanical deformation was observed toward the positive end of Cell 2. Based on photographs I analyzed from the inspection, it appears these two cells were placed into a 2D X-ray machine, although I have not reviewed any 2D X-ray images directly. A photograph of the 2D X-ray imaging process is shown in Figure 11. The positive top cap assembly of Cells 1 and 2 appeared to have a five-vent hole design.

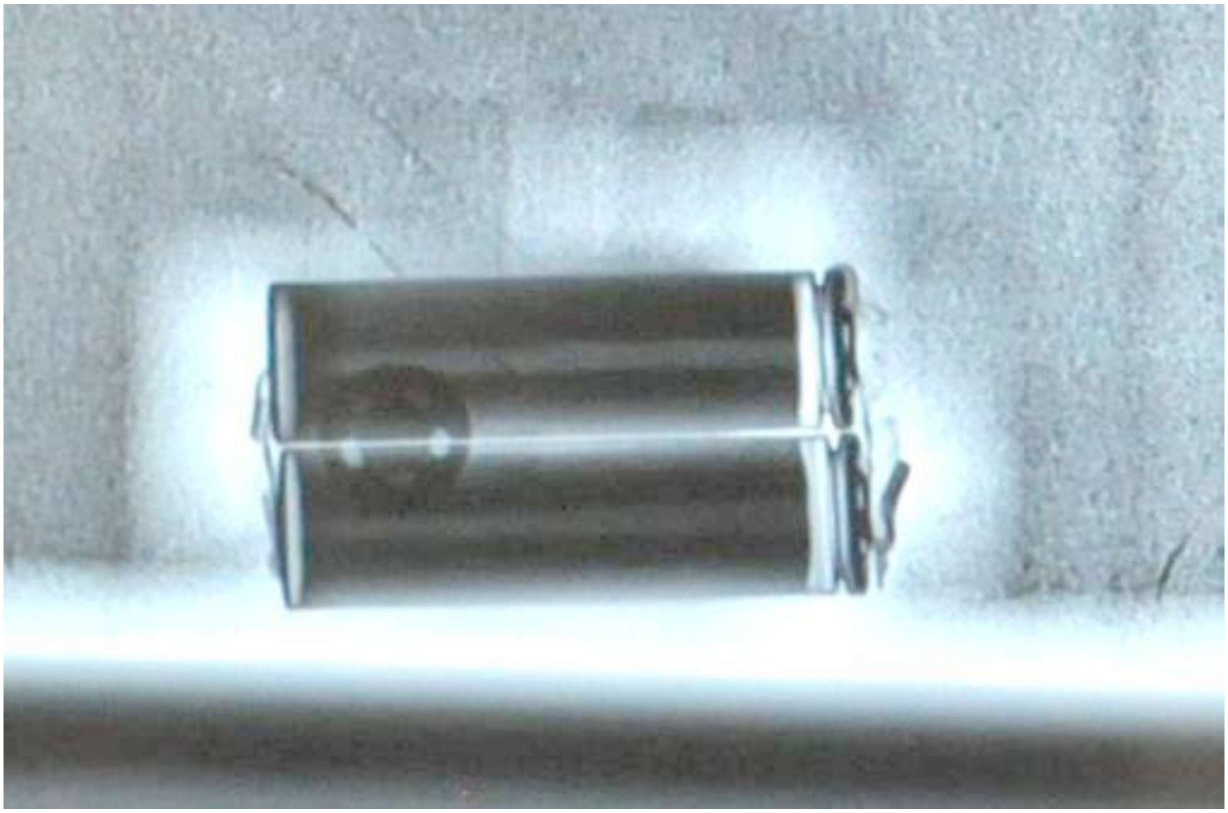


Figure 12. Photograph of a 2D X-ray image of Cells 1 and 2 (Don Galler photo 008).

The cans of Cells 3 and 4 were found remaining inside the battery pack region of the Subject Notebook, as shown in the photographs in Figure 13 and the 2D X-ray image in Figure 14.

Figure 13. Annotated photographs of the Subject Notebook battery pack remains a) top, and b) bottom. The red arrows indicate the cell cans remaining inside the pack.

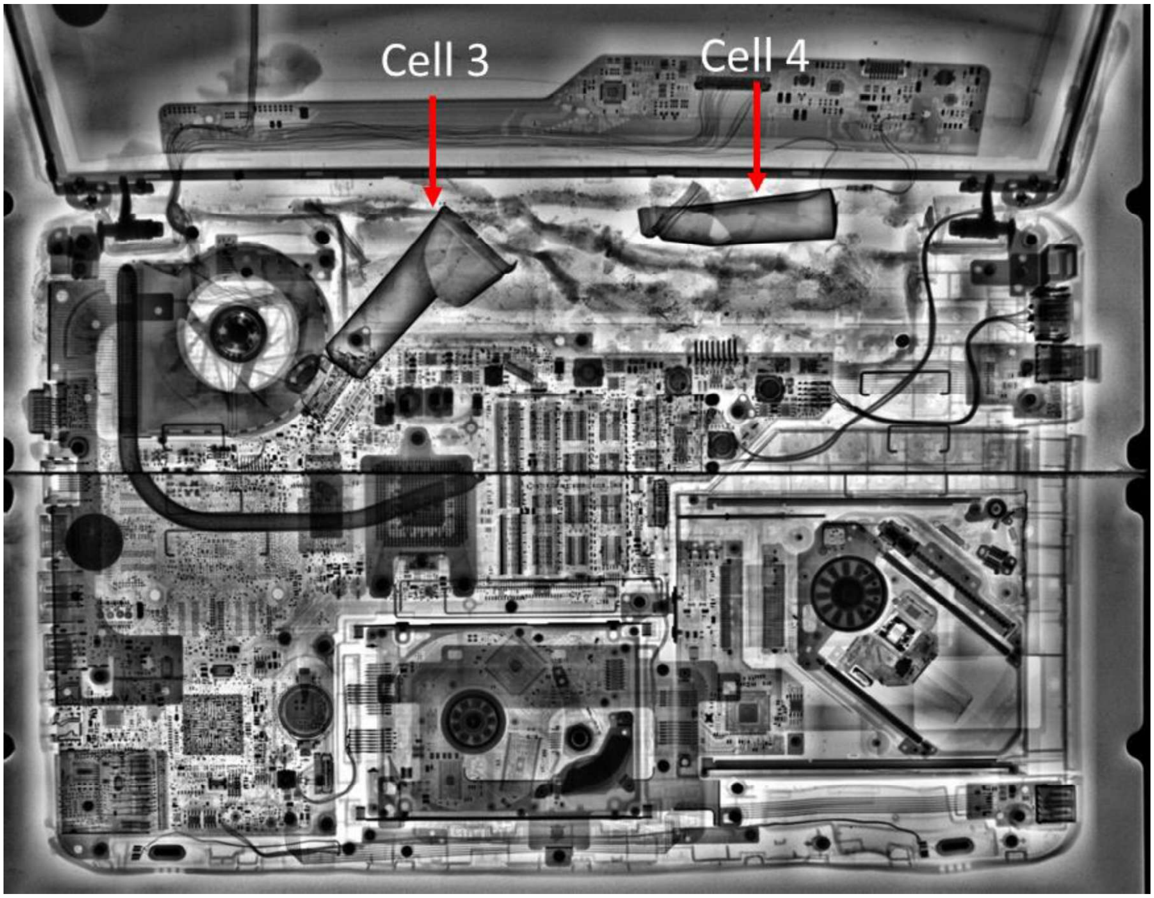


Figure 14. 2D X-ray image of the Subject Notebook including Cells 3 and 4 (received as part of the data from the lab examination).

Both cell cans had ruptured and torn, decrimping and detaching the positive top cap assembly in the process. Some windings remains were observed inside the Cell 3 can, but limited windings were found in the Cell 4 can or in the region directly around the notebook – most of the recovered windings were found on the floor on the other side of the room. Additional photographs of the two cells, after they were extracted from the notebook, are shown in Figure 15. Purple wrapper residue was observed on the surface of Cell 4.

Figure 15. Photographs of a) Cell 3 (Don Galler photo 318) and b) Cell 4 (Don Galler photo 321) of the subject battery pack after extraction from the Subject Notebook.

Cells 5 and 6, recovered in the corner of the office behind the desk during the scene inspection, were also examined at the lab inspection. Photographs of these cells are shown in Figure 16. Both cell cans had decrimped, and the positive top cap assembly had detached from the cell cans. No wrapper residue was observed on either cell; however, a thick green polymeric residue was observed to be melted to the Cell 6 can. The color of this substance was similar to that of a green melted handle to a bag recovered from the same area of the office, as shown in Figure 17.

Figure 16. Photographs of a) Cell 5 (Don Galler photo 262) and b) Cell 6 (Don Galler photo 266) of the subject battery pack.

Figure 17. Photograph of a bag recovered in the corner of the office (Don Galler photo 273)

At the end of the inspection, the subject battery pack BMS board was extracted from the notebook. Images of the front and back of the board are shown in Figure 18. Debris from the thermal incident was seen on the surface of the board, but limited thermal damage to board components was observed.

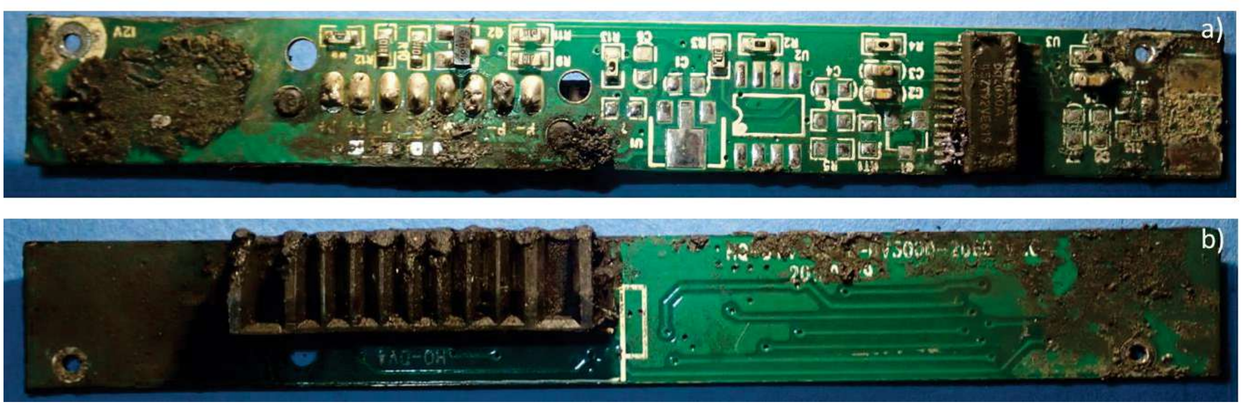


Figure 18. Photographs of the subject BMS a) front (Don Galler photo 366) and b) back (Don Galler photo 365)

3 Basis for Opinion 1

Opinion 1: The battery pack of the alleged subject HP Pavilion DV6 notebook computer was inconsistent with the genuine, original battery pack that would have been sold with this HP model. As such, protections provided by the original pack were not present in the battery pack that was installed in the notebook at the time of the fire, which could have led to degradation of the performance and safety characteristics of the cells.

3.1 Inconsistency of the subject pack with a genuine battery pack that was sold with this notebook computer

The basis for my opinion that the subject battery pack is inconsistent with the battery pack sold with this HP notebook is based on four factors:

i.) The labeling on the subject pack was inconsistent with that described in the product specifications for the original battery pack.

ii.) The physical construction of the cells in the subject battery pack are inconsistent with cells that were in the original battery pack that was sold with this HP notebook model.

iii.) The battery management system (BMS) layout and safety protections are inconsistent with the BMS of a genuine battery pack sold with this HP notebook model.

iv.) The Subject Notebook was manufactured in 2010 and sold in early 2011, making it 9 years old at the time of the fire. Based on an expected life cycle of the battery pack, it is unlikely that the original battery pack would still be installed if the notebook was still in use at the time of the fire.

3.1.1 Labeling

Based on a document provided by HP[3], the subject notebook computer was sold and shipped with a battery pack manufactured by LG Chem, containing LG cells. A comparison between the labeling on the subject pack and labeling from the LG product specifications[4] is shown in Figure 19.

[3] HP 00481

[4] HP 01324 - 01326

Figure 19. Comparison of the battery pack labeling in a) the subject pack (Don Galler photo 354), b) the subject pack (Don Galler photo 355), c) the original battery pack specifications (HP 01324) and d) the original battery pack specifications (HP 01324)

The remaining labeling on the subject pack appears inconsistent with that of the original battery pack, per the specifications. Labels are provided as part of the certification process, making them a known consistent characteristic across pack models, so the difference in labeling between the subject pack and the original battery pack is demonstrative of the fact that the subject battery packs was not an HP approved battery pack for the HP Pavilion DV6 notebook computer. This was further corroborated by Lee Atkinson, HP designee, during his deposition taken August 2, 2023.

3.1.2 Cell Model

The LG Chem battery pack that would have been sold with this notebook model was manufactured with LG cells. Documents provided by HP indicate that the specific cell model was an LG 18650B4 battery model. There are clear differences in construction between the cells from the subject pack and the LG 18650B4 cell. In my experience, the LG 18650B4 cell positive top cap assemblies have four vent holes and four weld marks that connect the positive cap to the burst disk. The cells for the subject pack, as shown in Figure 20, had five vent holes in the positive top cap assembly. Further, LG 18650B4 battery cells have gray wrappers, whereas the cells in the subject battery pack were clearly wrapped with purple wrappers based on the remains recovered at the scene. Additional differences in physical construction would likely have been identified through 3D CT scanning or high magnification 2D X-ray imaging of the cells recovered at the scene. At the time of writing this report, I have not seen any such images or data except for a CT

scan of the notebook with two of the six cell cans remaining inside. CT analysis of the remaining four cells may provide more product identification information as well as additional relevant information.

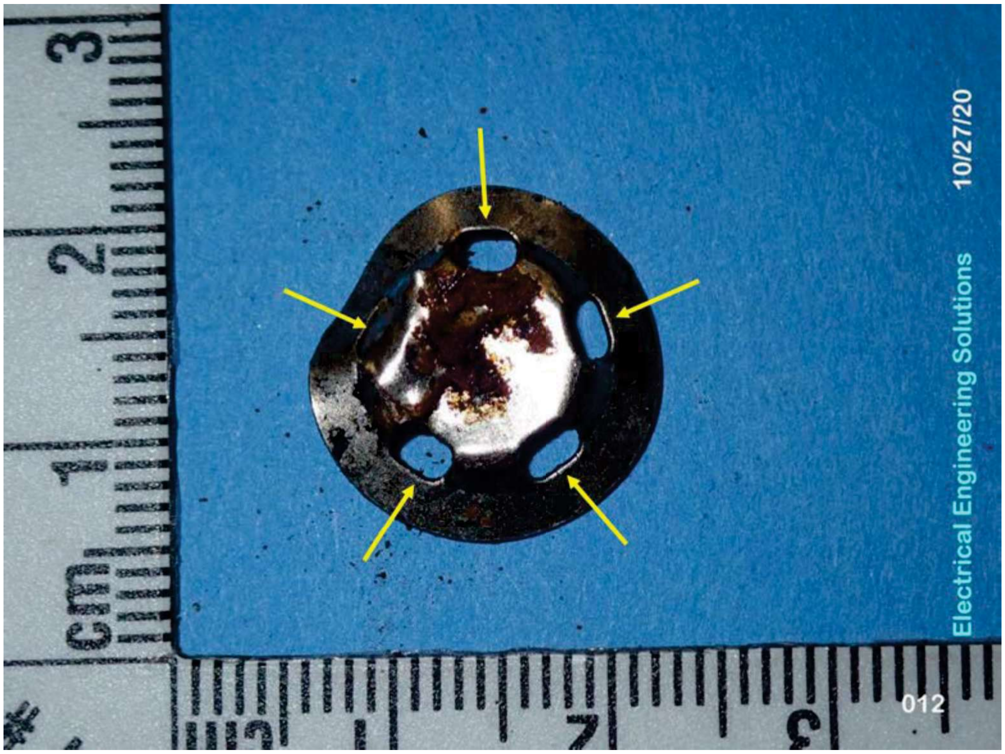


Figure 20. Photograph of a loose battery cell positive cap recovered from the scene at point "A" identified by the scene investigators (Don Galler photo 12). Yellow arrows indicate the five vent holes in the cap.

3.1.3 BMS

The BMS board extracted from the Subject Notebook during the lab examination had a different construction and lacked multiple protection features contained in genuine, exemplar packs for the Subject Notebook model. Figure 21 shows images of the board after cleaning at the lab examination. As seen in these images, there are two solder pads on either side of the board that are intended for wires to interface with the battery cells in the pack. These wires would only be capable of measuring the overall pack voltage, and as such individual cell block voltage measurement, or cell balancing as a result of that voltage measurement, would not be possible. In addition, there are no pads consistent with the connection of thermistors or thermocouples for cell surface temperature measurement. Further, there is no fuse on the board that could disconnect the battery pack in the event of an over-current situation. Individual cell voltage monitoring, temperature measurement, and a fuse are all required protection features (amongst others) that are present on the genuine LG Chem battery pack.[5] The fact that none of these features are possible with the subject BMS is another indication that the battery pack was not genuine.

[5] HP 01297 – HP 01334

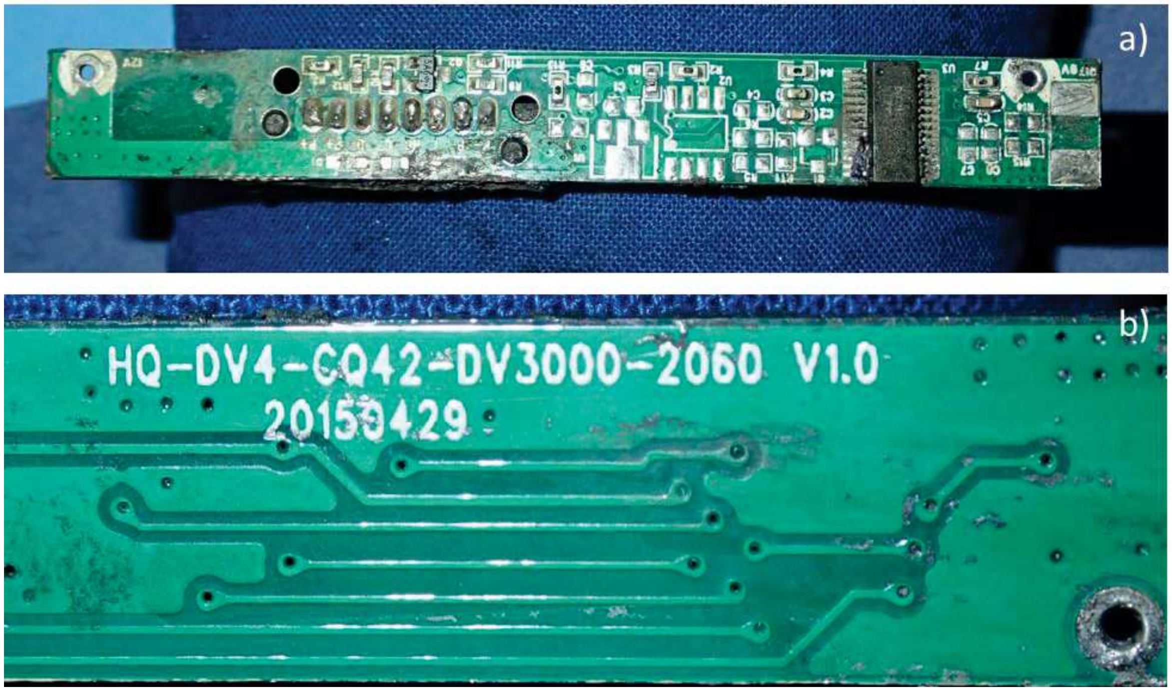


Figure 21. Photographs of a) the front side of the subject BMS board (Don Galler photo 386) and b) the back side of the BMS board after cleaning (Don Galler photo 377)

3.1.4 Manufacturing Dates, Purchase Dates, and Pack Lifetime

The original battery pack was manufactured in 2010, and the Subject Notebook was manufactured in February of 2011.[6] Plaintiff Carol Marcellin had registered the product for warranty on March 5, 2011, indicating that she had the notebook for almost 9 years prior to the fire.[7] In Ms. Marcellin's deposition, she stated that she would use the notebook daily for things such as emailing and online shopping.[8] Daily ordinary use of a notebook battery pack for 9 years would extend past the expected lifetime of the original battery pack, further corroborating that the battery pack installed in the notebook at the time of the fire was a replacement.

Lastly, the labeling on the back side of the board extracted from the Subject Notebook (see Figure 21b) indicates a manufacturing date of April 29, 2015. Thus, the battery pack must have been installed after the manufacturing and purchase dates of the notebook after April 29, 2015, and before the fire.

Based on clear differences in the labeling, the cell model/construction, BMS, and the purchase and use history of the notebook, it is my opinion that the subject battery pack is not a battery pack approved for use and/or sold with this HP notebook model. Rather, it is a pack of unknown manufacturing origin. See the Expert Report of Mr. Don Galler for more detailed analysis of the

[6] HP 00481

[7] HP 01336

[8] Deposition Transcript of Carol Marcellin, pp. 77:06 – 77:10

battery pack design and BMS function. Plaintiff Expert Dr. Martin also does not contest the fact that it is not an original HP battery pack.

3.2 There is no evidence of safety testing or certification of the subject battery pack

While the original battery pack and its component cells sold and shipped with the Subject Notebook are known to have undergone extensive safety testing and certification to industry safety standards such as UL 1642, UL 2054, and IEC 60950, the same cannot be said for the subject and exemplar battery packs that were manufactured by an unknown third-party. No documentation of safety and testing certification, either through a test certificate or a UL mark, was provided for either the pack or the associated cells, so the quality and safety of the components are unknown.

3.3 Lack of protections in the BMS could have led to degradation of cell safety characteristics or potential cell abuse

The battery management system (BMS) is a core component of the battery pack that communicates with the host system (notebook computer) to provide information about the state of the battery. The host system does not contain a separate BMS and does not have the means of monitoring the detailed state of the battery. This is consistent with the industry standard. This is why a properly implemented BMS is essential to ensure a safe battery pack. Pack-level safety testing, such as in IEC 60950, tests the ability of the BMS to prevent the battery cells from experiencing dangerous conditions, such as overcharge or overdischarge. No evidence of safety testing has thus far been provided for the subject battery pack, and so its implementation of safety measures through a properly designed BMS are unknown.

From examination of the evidence, it is clear that Incident Cells 3 – 6 experienced crimp release during the incident. Crimp release, where the positive cap of the battery cell is expelled, is an energetic failure mode; however, cells 1-2 appeared to have not experienced a thermal event at all. Such differences in relative damage patterns could be the result of cell imbalance at the time of the fire. Internal windings damage during thermal runaway is heavily dependent on the state of charge, and, based on an analysis of the BMS board of the subject pack, as described above, it is clear that the BMS did not have individual cell group voltage monitoring or any cell group balancing capabilities. As such, it is certainly possible that, during use and cycling of the pack, cell groups could have become imbalanced, or overcharge scenarios for cell groups could have occurred. An overcharge condition can occur due to poor cell balancing, or poor charge cutoff control, both of which are normally prevented by a properly designed and functioning BMS. Overcharge testing is part of the certification process, but without proper testing it would be possible for a poorly designed BMS in a battery pack to subject the cells to an overcharge condition. Such overcharge, imbalance, or other uses of battery cells outside their intended specification can result in degradation of the cell performance and safety characteristics, making them more susceptible to failure when exposed to other abuse conditions (e.g., external heat attack from a fire).

Based on my review of materials in this matter, the evidence is consistent with the battery pack experienced thermal runaway due to external heat attack from the fire (see Section 3); however, the installation and use of an after-market pack with this notebook increased the risk of its failure under any circumstances.

4 Basis for Opinion 2

Opinion 2: While the Subject battery pack was of unknown origin and lacked protection features that could prevent abuse of the included battery cells, the evidence is consistent with the subject battery pack experiencing thermal runaway due to external heat attack from the fire.

The basis for this opinion includes the following factors:

i) The location of the recovered battery cells and internal windings, combined with the thermal runaway damage patterns of the battery pack, suggest that cells inside the Subject Notebook were victims of external heat attack from the fire in the room of origin.
ii) 18650 battery cells, after being subjected to abuse conditions (or a lack of protection to keep them operating within specification) are more susceptible to failure when exposed to external stressors.
iii) The timeline of events and list of items in the room of origin at the time of the fire, as provided in Plaintiff depositions, is inconsistent with the fire initiating inside the Subject Notebook.

4.1 Evidence Locations and Damage Pattern Analysis

As discussed in Section 2, six 18650 battery cells were recovered in the alleged room of origin of the fire during the scene inspection, corresponding to the 3s2p configuration of the after-market battery pack installed in the Subject Notebook. A further annotated version of the room schematic is shown in Figure 22, where the boxes indicate locations of recovered cells/cell cans, green circles indicate locations of remains of cell windings, and blue circles indicate locations of ejected can material (e.g. positive top caps, can fragments, etc.). The red lines in the figure highlight the likely orientation of the armoire doors (where the Subject Notebook was found).

The area of the office with the highest levels of thermal damage was in the region surrounding the closet. The armoire doors and shelf on which the Subject Notebook was placed, which did not display any signs of scorching, burning, or other exposure to flaming cell ejecta, likely prevented most of the thermal runaway products from the battery cells in the notebook from being directed to the area of the closet. The only exception is a small windings fragment found in location K, and this fragment certainly could have moved as a result of firefighting or inspection.

Cells 1 and 2, found at location F in the center of the room, still had large fractions of the cell wrapper adhered to the cell cans, were still tabbed externally in their parallel configuration, and, based on the limited photographs of 2D X-ray imaging available for review, appeared to have almost entirely intact electrodes internally (see Figure 11 and Figure 12). These observations indicate that these cells did not experience thermal runaway. If these cells had experienced a failure that initiated the fire, it is highly unlikely that the amount of intact wrapper and intact

windings inside the cell would have been observed. This rules out these cells as potential initiators of the fire.

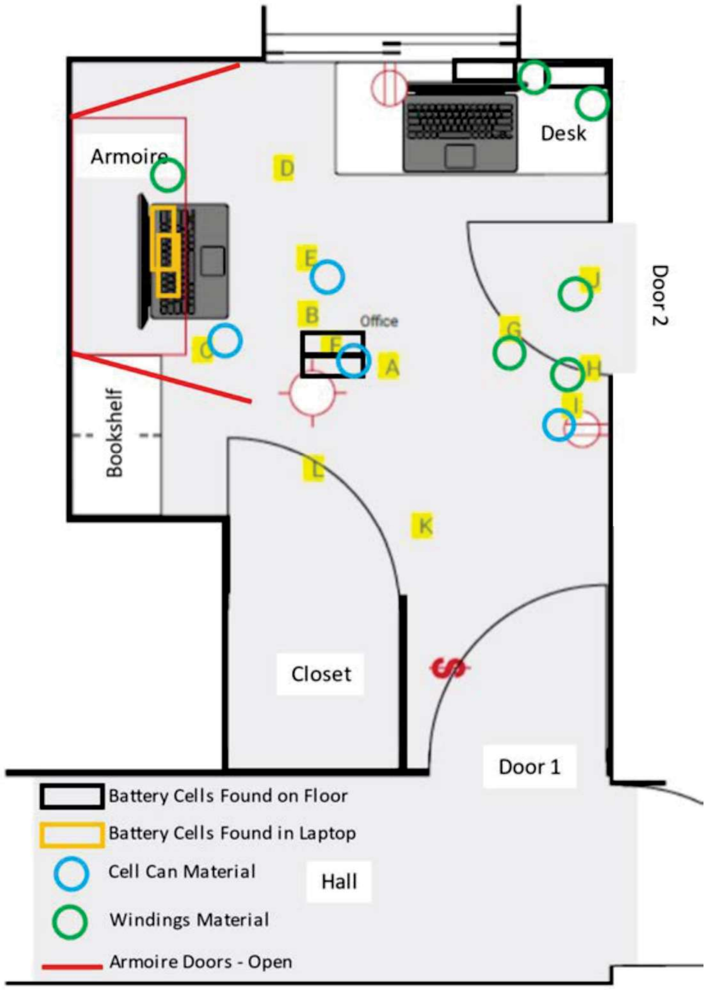


Figure 22. Annotated schematic of the office. The base schematic was taken from the expert report of Mr. Karasinski. Please see the key for the meaning of each added indication.

Cells 5 and 6 were found in the back corner of the office behind the desk. This region of the room exhibited the least thermal damage, and no combustibles near the floor level (such as the carpet, wooden desk, or desk chair) appeared to ignite during the event. This suggests that, at least by the time the cell cans reached their final location, they did not have enough energy to ignite nearby combustibles and materially spread the fire. Cells 5 and 6 also displayed signs of crimp release (see Figure 16), where the positive top cap assembly had ejected. Can fragments consisted with these cell top caps as well as winding fragments (that likely belong to some combination of Cells 3, 4, 5, and 6) were found at locations C, E, A/F, and I. While Cells 5 and 6 clearly experienced an energetic failure, the fact they that were found across the room, with other cell components in disparate locations, suggest that the notebook housing was already compromised at the time these cells experienced thermal runaway (thus enabling their escape due to the mechanical forces acting

on them during thermal runaway). As such, it is likely that these cells were victims of the fire or at least failed subsequent to the initiation of the event.

The remaining cans of Cells 3 and 4 were found in the battery pack region of the notebook. These cells had also experienced crimp release and high energy thermal runaway failures; however, a majority of their windings and can components were likely found in the center of the room, again suggesting that the notebook housing was compromised prior to their failure. Cell 4, which was observed towards the bottom of the notebook facing the armoire shelf, still had purple wrapper residue on the surface of the cell can, indicating that the cell ejected its contents, and their thermal mass, quickly enough such that the cell surface temperatures did not reach a point where the wrapper was consumed. Wrapper consumption would be expected if the fire was initiating in that cell.

In addition to the location and condition of the cell cans as observed at the scene, it is unlikely that any individual windings fragment, as were observed in evidence locations A – L in the scene photographs, would have had enough energy and thermal mass to ignite combustibles after traveling across the room. In my experience, based on extensive review of 18650 battery cells that have been subjected to UL 1642-style thermal runaway testing, when an 18650 battery cell experiences thermal runaway, hot gases, sparks, and particles will be ejected during the venting process. These materials can ignite combustibles that are directly nearby the failing cell, as these ejecta have not yet had time to cool as they travel; however, in the cases where pressure builds up in the cell such that decrimping occurs and the top cap is detached, subsequently enabling ejection of large portions of the cell windings, the cell can remains have less thermal mass and the ejected windings will cool quickly. In this case, where small fragments of windings were found in disparate locations throughout the room, it appears highly unlikely that any individual windings fragment would have had sustained the energy required to ignite materials across the room of origin from where the cells experienced thermal runaway inside the notebook.

4.2 External heat attack of 18650 battery cells after being subjected to abuse

During the development of a fire inside a small room, smoke and other hot gases rise to the ceiling and then radiate heat back down to the room contents. As the fire progresses, more gas is generated, and this "hot gas layer" at the ceiling level increases in thickness, growing downwards towards the floor. In fire investigations, the level of the hot gas layer can be investigated by examining the walls and ceiling for charring and other evidence of intense thermal damage caused by these hot gases. In this investigation, the hot gas layer, as indicated in Figure 4 and Figure 5, extended to the level of the Subject Notebook, essentially subjecting the notebook to radiant head as if it were in a large oven. See Dr. Timothy Meyers' report for more detailed analysis.

At the scene and lab examinations, it was observed that the plastic housing of the notebook exterior (around the screen) as well as the keyboard had melted during the incident (see Figure 4b, where the material had dripped down the surface of the screen and also on the sides of the notebook). The nature of the melting and resolidification of these materials suggests top down heating, likely from the fire or radiated heat from the hot gas layer of the fire.

According to the HP representative Mr. Lee Atkinson, these materials are comprised of ABS (acrylonitrile butadiene styrene), a thermoplastic polymer. While this polymer is amorphous and does not have an exact melting point, depending on the composition the material glass transition temperature would likely be in the range of 85 - 115 °C, and the process temperature (where it can flow into molds as if melted) is in the 230 – 270 °C range[9]. Exposure of a battery pack to temperatures in these ranges for any extended period of time could absolutely initiate self-heating and ultimately thermal runaway of cells installed in the pack, especially if they had been previously exposed to conditions outside specification.

As discussed in Section 3, the subject battery pack was inconsistent with a genuine pack installed in the Subject Notebook, and it lacked key protection features that would prevent the cells from being used outside their intended specifications. Using cells in this manner can degrade both their performance and safety characteristics and make them more susceptible to failure when exposed to subsequent stressors and/or abuse conditions, such as the scenario here where it appears that the pack was both charging and subjected to external heat attack from the fire. It is entirely possible that cell imbalance (or even direct overcharge) at the time of the fire (caused by the lack of protections in the BMS and continued use of the pack over years) exacerbated the severity of the cell thermal runaway when exposed to the fire, thus resulting in the damage pattern analysis described in this report.

In addition, the Subject Notebook was plugged in and charging at the time of the incident, as compared to the additional HP notebook on the desk in the office, which was not plugged in according to images taken at the scene. Thus, the Subject Notebook battery pack was likely at a higher state of charge and was more likely to enter thermal runaway when exposed to the fire as compared to the additional HP notebook.

4.3 Deposition Testimony

4.3.1 Timeline of events

According to Ms. Marcellin's deposition, the timeline of events after the smoke alarm went off inside the house consisted of the following[10]:

> *Q. Can you take me through the route that you took upon waking up on January 24th of 2020, using this diagram?*
>
> *A. Yeah. Chuck and I were sleeping in that lower – that bedroom on the lower side. I opened the door and silenced the fire alarm that's immediately outside on the wall there because I didn't want it frightening him. I could smell smoke. I knew there was something going on, hoping it was just the furnace. Maybe it had malfunctioned and was putting out smoke or something, and I could shut it down.*

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[9] Campo, E. A. (2013). The complete part design handbook: for injection molding of thermoplastics. Carl Hanser Verlag GmbH Co KG.

[10] Deposition transcript of Carol Marcellin, pp. 123:22 – 125:01

But I went back through the kitchen – past that bathroom, through the kitchen, and then I got into the living room. When I stepped to the right to go down that hall, I could see the glow of fire coming from that room where the notebook was.

I immediately backtracked into the kitchen, grabbed a fire extinguisher and hoped that when I got to the doorway I would be able to take care of it, but when I get there, it was already putting out fireballs, whatever they call them, from the battery pack apparently, sending them up to the ceiling. It was catching on fire and dropping from the ceiling, so I couldn't go in.

In my experience, thermal runaway of an 18650 battery cell completes in seconds once it has started. Based on this description of events, the fire had progressed sufficiently to trip the fire alarm before Ms. Marcellin entered the room. Ms. Marcellin subsequently observed "fireballs" from the notebook and fire "dropping from the ceiling." If this is when the cell thermal runaway events were occurring, then this would have been well after the fire had started.

The description of events is consistent with the notebook being exposed to external heat attack, and the installed battery cells being victims of the fire rather than initiators.

4.3.2 Evidence Items Remaining

Earlier in the deposition testimony, Ms. Marcellin also testified that there was another notebook computer inside the closet, as summarized in the following exchange:

Q. And you said that the Compaq from the '90s was in the closet in the office at the time of the incident; is that correct?

A. Yes. It's in a notebook bag inside the closet that's in the room.

Q. Was it on a shelf in the closet, on the floor, something else?

A. It sat on the floor.

If there was a notebook computer in the closet at the time of the fire, remains of the notebook would have been found during the scene inspection, when investigators cleared the closet of debris. Remains of clothing, plastic bin, and other flammable items were found in the closet during the scene investigation. If a notebook was in the closet, there would have been materials that were not melted or disintegrated during the fire and would have been present for inspection.

Similarly, no windings remnants from the cells that experienced thermal runaway in the Subject Notebook were found in the closet during the scene inspection. The copper foil, from the negative electrode windings, would melt at temperatures over 1000 °C, and it is unlikely that the fire reached those temperatures during the incident. Based on my review of the scene and lab inspection data, it does not appear that any cell or notebook remnants were found in the closet. As such, it appears that most, if not all of the cell ejecta was found in locations in the area of origin that experienced more limited thermal damage, and there was no obvious ignition pathway between the notebook, cell cans or cell ejecta, and the closet where a concentration of fuel burning

was observed. This provides further support that the Subject Notebook was exposed to external heat attack as a victim of the fire.

5 Comments Regarding the Opinions of Plaintiff Expert Dr. Steve Martin

Dr. Steve Martin submitted an Expert Report for the Plaintiff in this matter. Responses to statements and opinions made in his report are listed below. Note, this list may not contain all of my contentions with statements in Dr. Martin's report, and I reserve the right to further respond as needed.

5.1 On page 22 of Dr. Martin's report, he concludes: "The fire at issue in this case was caused by cell overcharge or overvoltage causing one or more cells in the battery pack to reach excessive temperatures and prompting a thermal runaway reaction."

Dr. Martin's assertion that the fire was definitively initiated inside the notebook, and, further, was initiated via overcharge, is not substantiated by the evidence and analysis that has been completed in this matter. As discussed in Section 4, analysis of the remains of the battery cells observed at the scene, the notebook, and their associated remnant locations in the alleged room of origin of the fire are more indicative of the Subject Notebook failing as a result of external heat attack from a fire already in progress.

Dr. Martin alleges a specific failure mode of a battery pack without identifying the initiating cells, without having done any mass measurements, 2D X-ray analysis, or CT scans of the cells that were ejected from the Subject Notebook, and without considering the totality of the circumstantial evidence, including analysis of the Plaintiff deposition as it corresponds to what was observed at the scene investigation. As such, he has not performed the analysis required to make any determinative statements about the initiation or more specifically the method of initiation of thermal runaway in the after market battery pack that was installed in the Subject Notebook at the time of the fire.

6 Comments Regarding the Opinions of Plaintiff Expert Jason Karasinski

Mr. Karasinski submitted an Expert Report for the Plaintiff in this matter. Responses to statements and opinions made in his report are listed below. Note, this list may not contain all of my contentions with statements in Mr. Karasinski's report, and I reserve the right to further respond as needed.

6.1 On page 45 of Mr. Karasinski's report, he concludes: "Based on the totality of the investigation, the cause of the fire was a failure of the HP Pavilion notebook system, to include the battery pack. This failure resulted in the ejection of hot battery material that ignited combustibles located within the room of origin, to include the closet.

Please refer to the report of Dr. Timothy Meyers for a full analysis of the fire origin and cause in this matter; however, as I discussed in Section 4 of this report, it is highly unlikely that a single fragment of battery remains ignited combustibles in the closet without any set of battery material found in the closet during examination. Copper windings, which melt above 1000 °C, if they were present in enough bulk, and with enough energy remaining after traveling across the room from the notebook to ignite combustibles, would likely still remain in the ignition area after investigation. No such remains were found in the closet.

Further, Mr. Karasinski fails to explain how multiple cell cans and the rest of the battery related evidence observed during scene inspection were located in areas of the alleged room of origin that experienced minimal fire damage and showed no evidence of combustible ignition at the floor level. It appears that, in the absence of an observed ignition source that would be consistent with the fire damage patterns observed in the room, Mr. Karasinski has attributed the initiation of the fire to the notebook without sufficient evidentiary proof to support that claim.

Limitations

At the request of Coughlin Betke LLP, Exponent conducted an evaluation of the fire that occurred on January 24, 2020 at 192 Bell Brooks Road in Ceres, New York.

Any re-use of this report or its findings, conclusions, or recommendations presented herein are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

The findings presented herein are made to a reasonable degree of scientific and engineering certainty. If new data becomes available or there are perceived omissions or misstatements in this report regarding any aspect of those conditions, we ask that they be brought to our attention as soon as possible so that we have the opportunity to fully address them.

Appendix A – Material Reviewed

1. Report of Jason Karasinski, dated October 14, 2024
2. Report of Dr. Steve Martin, dated October 14, 2024
3. Report of Andy Litzinger, dated October, 2024
4. Allegany County Fire Investigation Report
5. Deposition of Plaintiff Carol Marcellin
6. Deposition of Lee Atkinson
7. Scene inspection notes and photographs of Greg Gorbett
8. Lab inspection notes and photographs of Don Galler
9. HP Production Documents
10. Plaintiff Production Documents
11. Written discovery responses and other miscellaneous case discovery material
12. O. Bankole, C. Gong, and L. Lei, "Battery Recycling Technologies: Recycling Waste Lithium Ion Batteries with the Impact on the Environment In-View", *Journal of Environment and Ecology,* **4,** 1 (2013)
13. L. Yuan *et al.*, "Experimental study on thermal runaway and vented gases of lithium-ion cells", *Process Safety and Environmental Protection*, **144**, (2020), pg. 186-192.
14. National Fire Protection Association Guide for Fire and Explosion Investigations, 2017.
15. Thomas B. Reddy. 2011200219951984. "APPENDIX H: METHODOLOGIES FOR BATTERY FAILURE ANALYSIS." Chap. in Linden's Handbook of Batteries, Fourth Edition. Fourth. McGraw-Hill Education: New York, Chicago, San Francisco, Athens, London, Madrid, Mexico City, Milan, New Delhi, Singapore, Sydney, Toronto.
16. UL 1642
17. UL 2054
18. IEC 60950

Appendix B – Curriculum Vitae

Exponent®
Engineering & Scientific Consulting

Quinn Horn, Ph.D., P.E.
Principal Engineer | Materials and Corrosion Engineering
Natick
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Professional Profile

Dr. Horn consults in the areas of metallurgy and electrochemistry and frequently addresses issues related to corrosion analysis, battery manufacturing, and battery science. In the field of metallurgy, he consults on topics related to failure analysis, corrosion, material degradation, and material selection.

In the field of battery technology, Dr. Horn's work addresses a broad range of issues including material selection and testing, cell design, cell manufacturing, performance degradation, accelerated life testing, and due diligence technology evaluation. He has extensive experience developing characterization techniques for understanding discharge reactions and degradation mechanisms in a wide range of battery systems including lithium-ion, lithium-primary, nickel-metal hydride, nickel cadmium, lead-acid, and alkaline primary cells.

Prior to joining Exponent, Dr. Horn held positions as a Principal Scientist at Physical Sciences Inc. (PSI), and as a Staff Technology Engineer at Energizer/Eveready Battery Company. At PSI, Dr. Horn designed, developed, and tested high-energy and high-power electrodes for lithium-ion batteries. At Energizer, Dr. Horn was responsible for the Microscopy and Materials Group, where he conducted failure analysis studies to solve problems related to battery failures and battery manufacturing issues.

Dr. Horn is a Research Affiliate at the Massachusetts Institute of Technology, where he collaborates with researchers in the Electrochemical Energy Laboratory on projects related to electric vehicles and new gas diffusion electrodes for metal-air batteries and fuel cells.

Academic Credentials & Professional Honors

Ph.D., Metallurgical and Materials Engineering, Michigan Technological University, 1998

M.S., Metallurgical Engineering, Michigan Technological University, 1995

B.S., Metallurgical Engineering, Michigan Technological University, 1993

Iron and Steel Society's Young Leaders Award, 1997-1998

DeVleig Academic Fellowship, 1997

Department of Defense Research Fellow, 1994-1997

Forging Industry Education and Research Foundation's Forging Achievement Award, 1992

Licenses and Certifications

Professional Engineer, Maryland, #38382

Academic Appointments

Research Affiliate, Mechanical Engineering, Massachusetts Institute of Technology

Prior Experience

Principal Scientist, Physical Sciences Inc., 2002-2004

Staff Technology Engineer, Eveready/Energizer Battery Company, 1998-2002

Professional Affiliations

Materials Research Society, 2001-present

Electrochemical Society, 1999-present

Tau Beta Pi, 1992-present

Alpha Sigma Mu, 1991-present

ASM/TMS, 1991-present

Patents

Patent 7,709,139: Three Dimensional Battery, May 4, 2009 (with K. White, E. Salley and J. Lennhoff), May 4, 2010.

Patent 7,332,247: Electrode for an Electrochemical Cell and Process for Making the Electrode, February 19, 2008.

Patent 7,229,944: Fiber Structures Including Catalysts and Methods Associated with the Same, June 12, 2007 (with Y. Shao-Horn and J. Kurpiewski).

Patent Application 12/193,482: Carbon Foam Based Three Dimensional Batteries and Methods, filed August 18, 2008 (with K. White and A. Newman).

Publications

Book Chapters

Horn Q, Hayes T, Slee D, White K, Harmon J, Godithi R, Wu M, Megerle M, Singh S, Mikolajczak C. Methodologies for Battery Failure Analysis. In: Handbook of Batteries (4th edition), Thomas Reddy (ed), McGraw-Hill, October 2010.

Publications

Han B, Harding JR, Goodman JKS, Cai Z, Horn QC. End-of-Charge Temperature Rise and State-of-Health Evaluation of Aged Lithium-Ion Battery. 2022 December, Energies 16 (1), 405.

Cohn AP, Hayes TA, Harding JR, Horn QC. The Low-Voltage Limits of Lithium-Ion Batteries—Overdischarge and Degradation from a Safety Perspective, 2022 October, ISTFA 2022, 47-50.

Harding JR, Han B, Madden SB, Horn QC. Examining the performance of implantable-grade lithium-ion cells after overdischarge and thermally accelerated aging. 2022 February, Energies 15 (4), 1405.

Ponchaut NF, Colella F, Spray R, Horn Q. Thermal management modeling for avoidance of thermal runaway conditions in lithium-ion batteries. Lithium Ion Batteries in Electric Drive Vehicles, 2016 May, 175, 75.

Ponchaut N, Marr K, Colella F, Somandepalli V, Horn Q. Thermal runaway and safety of large lithium-ion battery systems. Proceedings of the The Battcon, 2015 May, 17.1-17.10.

Ponchaut NF, Colella F, Spray R, Horn Q. Thermal management modeling for avoidance of thermal runaway conditions in lithium-ion batteries. SAE Technical Paper, 2014.

Somandepalli V, Marr K, Horn Q. Quantification of combustion hazards of thermal runaway failures in lithium-ion batteries. SAE International Journal of Alternative Powertrains 3 (2014-01-1857), 98-104.

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Selected Presentations

Horn Q. Failure modes unique to large format cells and battery systems. NAATBatt Annual Meeting and Symposium, San Diego, CA, January 21-23, 2014.

Horn Q. Review of battery technology and safety. Canadian Arson and Fire Investigator's Educational Symposium and Seminar, Niagara Falls, Ontario, September 17-19, 2013.

Horn Q, White K. Characterization of degradation and failure modes in lithium-ion cells. Invited Presentation, Microscopy and Microanalysis 2013 Meeting, Indianapolis, IN, August 6, 2013.

Somandepalli V, Marr K, Horn Q. Catastrophic failures in lithium-ion battery packs used in EV and hybrid vehicles. Society of Automotive Engineers, 2013 World Congress, Detroit, MI, April 16-18, 2013.

Somandepalli V, Marr K, Horn Q. Explosion hazards due to failures of lithium-ion batteries. American Institute of Chemical Engineers, 2012 Spring National Meeting, 9th Global Congress on Process Safety, San Antonio, TX, April 28-May 1, 2013.

Spray R, Forman J, Horn Q, Shah K, White K. Towards an accessible methodology for measurement of cell performance with aging. 30th Annual International Battery Conference, Fort Lauderdale, FL, March 2013.

White K, Horn Q. Predicting long term lithium-ion battery performance through the application of chemical kinetics. MD&M West Meeting, Anaheim, CA, February 14, 2013.

White K, Somendapalli V, Mahr K, Horn Q. Combustion properties of Li-ion battery vent gases. IEEE Product Safety Symposium, Portland, OR, November 2012.

Somandepalli V, Marr K, Horn Q. Combustion properties of Li-ion battery vent gases. 29th International Battery Seminar and Exhibit, Fort Lauderdale, FL, March 2012.

Horn Q. Performance and reliability of batteries for medical device applications. Invited presentation at the MD&M West Meeting, Anaheim, CA, February 15, 2012.

White K, Horn Q. Quantifying lithium-ion battery safety. IEEE Product Safety Symposium, San Diego, CA, November 2011.

Horn Q. Characterizing performance and determining reliability for batteries. Invited presentation at the MD&M Minneapolis Meeting, Minneapolis, MN, November 1, 2011.

Horn Q, White K, Spray R. Mapping thermal stability of lithium-ion cells. Invited presentation at the Dow-Kokam Advanced Battery Technology Exchange, Lee's Summit, MO, October 20, 2011.

Horn Q, Qi Y. Materials for li-ion batteries: Structures, performance, and durability. Short course taught at the 219th Electrochemical Society Meeting, Montreal, Canada, May 1, 2011.

Horn Q, White K. Cell overcharge in the absence of battery management unit failure. Presented at the Electric Vehicle Lithium-Ion Battery Forum, Beijing, China, August 25, 2010.

Horn Q, White K, Singh S. Assessing thermal stability of commercial lithium-ion cells. Presented at the International Meeting on Lithium Batteries, Montreal, Canada, July 2, 2010.

Horn Q. Inside the battery: Understanding why good batteries go bad. Invited keynote presentation, Teradyne Users Group Conference, Hilton Head, SC, May 3, 2010.

Horn Q, White K. Characterizing performance and determining reliability for batteries in medical device applications. Presented at ASM Materials and Processes for Medical Devices, Minneapolis, MN, August 13, 2009.

Horn Q. Battery involvement in fires: Cause or effect? Invited seminar, International Association of Arson Investigators- Massachusetts Chapter, Auburn, MA, March 19, 2009.

Horn Q, White K. Advances in characterization techniques for understanding degradation and failure modes in lithium-ion cells: Imaging of internal microshorts. Invited presentation, International Meeting on Lithium Batteries 14, Tianjin, China, June 27, 2008.

Horn Q, White K. Novel imaging techniques for understanding degradation mechanisms in lithium-ion batteries. Presented at the Advanced Automotive Battery Conference, Tampa, FL, May 13, 2008.

Horn Q. Application of microscopic characterization techniques for failure analysis of battery systems. Invited presentation, San Francisco Section of the Electrochemical Society, March 27, 2008.

Horn Q. Technological challenges in portable energy storage. Invited presentation, 5th Global Technology Symposium at Stanford, Palo Alto, CA, January 31, 2008.

Horn Q, White K. Understanding lithium-ion degradation and failure mechanisms by cross-section analysis. Presented at the 211th Electrochemical Society Meeting, Chicago, IL, Spring 2007.

Hayes T, Horn Q. Methodologies of identifying root cause of failures in li-ion battery packs. Invited presentation, 24th International Battery Seminar and Exhibit, Fort Lauderdale, FL, March 2007.

White K, Newman A, Boehme J, Middleton C, Pawle R, Middleton E, Lennhoff J, Horn Q, Shao-Horn Y. Anode and cathode templated three-dimensional lithium-ion batteries based on nano-fibrous electrodes. Invited presentation, 208th Electrochemical Society Meeting, Los Angeles, CA, Fall 2005.

Horn Q. Lithium-ion batteries with three-dimensional electrode architectures. Invited presentation, Energizer Battery Company, Westlake, OH, May 3, 2005.

Horn Q, Kurpiewski J, Shao-Horn Y. Engineered electrodes and membrane electrode assemblies for PEM fuel cells. Presented at the ASME Congress, Anaheim, CA, November 15, 2004.

Lennhoff J, Rose A, Hunter A, Harris G, Horn Q. Storage of ammonia in metal organic frameworks. Invited presentation, Nano Materials for Defense Applications Meeting, Maui, HI, February 2004.

Horn Q, White K, Shao-Horn Y, Lennhoff J. Three dimensional lithium ion batteries based on non-woven carbon fabrics. Presented at the 204th Electrochemical Society Meeting, Orlando, FL, Fall 2003.

Horn Q, Shao-Horn Y. Morphology and spatial distribution of ZnO discharge product in commercial Zn/MnO2 AA batteries. Presented at the International Battery Association/Hawaii Battery Conference Joint Meeting, Waikola Beach Resort, HI, January 2003.

Horn Q, Heckel R, Nassaralla C. The effect of magnesium additions on the evolution of PH3 gas from FeSi75 alloys. Presented at the 56th Electric Arc Furnace Conference, New Orleans, LA, November 1998.

Horn Q, Heckel R, Nassaralla C. Microstructural study of granulated ferrosilicon with 75wt% silicon. Presented at the INFACON 8 Meeting, Beijing, China, June 1998.

Horn Q, Heckel R, Nassaralla C. Reactive phosphides in commercial ferrosilicon. Presented at the Iron and Steel Making Conference, Chicago, IL, April 1997.

Horn Q, Heckel R, Nassaralla C. Interaction of ferrosilicon alloys with the environment. Presented at the Japan-U.S. Joint Seminar for Clean Steel for the 21st Century, Futtsu, Chiba, Japan, April 25-27, 1996.

Seminars and Short Courses

"Investigating the Potential Involvement of Batteries in Fires"

- IAAI International 67th Training Conference, April 24-29, Orlando, Florida, 2016.
- IAAI Hawaii Chapter Training Seminar, August 10-12, Honolulu, Hawaii, 2016.
- New York State Office of Fire Prevention and Control 42nd Arson Seminar, New York State Academy of Fire Sciences, November 2-4, 2016.
- UK Association of Fire Investigators Annual Training Conference, Chesam, Bucks, UK, January 30-31, 2017.

Appendix C – Testimony List

Below is a list of my deposition and trial testimony over the last four years.

1. **Amperex Technology Limited v Semiconductor Energy Laboratory Co., Ltd.**
   United States District Court Eastern Division of Virginia, Alexandria Division
   Civil Action No. 1:23-cv-272-PTG-LRV
   Deposition, August 20, 2024

2. **Hayward Industries, Inc. v Blueworks Corporation, et al.**
   In the United States District Court for the Western District of North Carolina, Charlotte Division
   Civil Action No. 3:20-CV-710 -MOC-DSC
   Trial, February 23, 2024

3. **Philadelphia Indemnity Insurance Company v Hewlett-Packard Company**
   United States District Court, Western District of Washington at Seattle
   Case No.: 2:19-cv-00138-TL
   Trial, October 19, 2023

4. **Varta Microbattery GMBH v Audio Partnership LLC and Audio Partnership PLC d/b/a Cambridge Audio**
   United States District Court, Eastern District of Texas, Marshall Division
   Civil Action No. 2:21-cv-00400-JRG-RSP
   Deposition, September 19, 2023

5. **Varta Microbattery GMBH v Audio Partnership LLC and Audio Partnership PLC d/b/a Cambridge Audio**
   United States District Court, Eastern District of Texas, Marshall Division
   Civil Action No. 2:21-cv-00400-JRG-RSP
   Deposition, August 14, 2023

6. **Varta Microbattery GMBH v Audio Partnership LLC and Audio Partnership PLC d/b/a Cambridge Audio**
   United States District Court, Eastern District of Texas, Marshall Division
   Civil Action No. 2:21-cv-00400-JRG-RSP
   Deposition, May 26, 2023

7. **Philadelphia Indemnity Insurance Company, a Pennsylvania corporation, as subrogee of DH&G, LLC v Hewlett-Packard Company**
   United States District Court, Western District of Washington
   Case No.: 2:19-cv-00138-RSM
   Deposition, February 28, 2023

8. **In the Matter of: Certain Lithium Ion Batteries, Battery Cells, Battery Modules, Battery Packs, Components thereof, and processes therefor**
   United States International Trade Commission
   Inv. No. 337-TA-1159
   Deposition, January 17-18, 2020